ADDRESS OF THE RETIRING PRESIDENT OF THE SOCIETY, AT THE SECOND ANNUAL MEETING (MARCH 29, 1890).

By Edward S. Holden.

It is customary in scientific societies for the retiring President to deliver an address at the end of his term, choosing some subject closely related to the special object of the society's existence. I may claim, perhaps, unusual freedom in conforming to this custom, because I have already delivered such an address "On the Work of an Astronomical Society" at our first annual meeting.* It would be of great interest to review the work of the Society during the past year, and to consider the very useful relations in which we are already established. Perhaps, however, it is too soon for such a detailed review, and I may leave it to my successor, and choose a different topic. It will not be out of place to summarize the statistics of the first year of the Society, in the briefest way. We began our existence very modestly and simply, on the 7th of February, 1889, with a membership of forty, almost all citizens of San José or San Francisco. At this time we have 192 members (27 life, 165 active), and they are scattered from London to Venezuela, from Mexico to British Columbia, and in the United States from Boston and New York to California. Beside this, we regularly send our *Publications* to nearly one hundred observatories, academies of science, libraries and public institutions distributed all over the world, in England, France, Spain, Portugal, Italy, Germany, Austria, Russia, Denmark, Sweden, in Africa, Asia, Australia and the islands of the Pacific, in both North and South America. Whoever contributes a paper to our *Publications* is addressing not only our small audience of California amateur and professional astronomers, but he is speaking directly to the whole world of astronomy and of astronomers. There is no cause to fear such an audience. No one is so well able to estimate the spirit in which any piece of faithful work is done as the professional observer, who knows what infinite pains are necessary to accomplish great tasks —not only what pains, but what native abilities are needed. If we are, as I have said, active, alive, modest, competent, we may be sure that our work will be received and welcomed on account of the spirit in which it is done; and that its amount and lasting value will be generously and not grudgingly weighed. We have already to thank

***Publications* A. S. P. No. 2.

the courtesy of many distinguished institutions and individuals for the welcome our work has received at their hands. Such a welcome will teach us to hold our ideals high, while, at the same time, we must be willing to take the little steps that are necessary to advance, and not be discouraged if our present progress is not by strides, as we might wish.

Our *Publications* have presented the work of the astronomers and of the students of the Lick Observatory chiefly (as was natural during the first year of our existence). We have, however, a number of other papers promised or on hand from non-members of the Society. I must, however, repeat what I said in my former address, that the amateur members of the Society should fill the first part of our papers. The *Notices from the Lick Observatory* afford a field for presenting the work of our professional members in California, and they seem to have served a useful purpose thus far.

We should not allow this occasion to pass without a grateful acknowledgment of the material contributions which we owe to several of our members, which have already been serviceable to science. The eclipse expedition, sent out at the expense of Colonel CROCKER, has been fully successful, and our knowledge of this eclipse will rest upon the observations of the South American parties alone. The Lick Observatory party has secured fourteen satisfactory photographs, some of them of great importance.

The comet-medal founded by Mr. DONOHOE will promote the discovery and encourage the observation of comets, not only now but always. In my view, the attitude taken by the Society and by the founder of this medal is precisely the right one. We are eager to commemorate each piece of useful work done in this direction, and we desire to recognize the merit of the discoverers of comets; but we are far from thinking that any reward for such labors can be given. The reward is the discovery itself. It was fortunate for the Society that Mr. DONOHOE was able to be in Paris, and to attend personally to the matter of selecting the beautiful designs for this medal, which is a real work of art.

The generous gift of the MONTGOMERY Fund will be used to establish a library for the members of the Society in San Francisco. A solid nucleus for the MONTGOMERY Library will be purchased outright and at once; a portion of the fund will be invested, and the interest applied to increasing our collections. Exchanges with other scientific societies and with observatories will yield us many most valuable and important works, and our thanks are due to the correspondents who have already contributed to the Society Library, and

also to the Smithsonian Institution, which transmits these gifts to us without charge.

I think that one of the best uses of the Society will be to help to place before the people of our State, directly and indirectly, the purposes for which observatories are founded and the problems which astronomy has now to consider. These are very little understood anywhere, and perhaps less so in California than in any other equally intelligent community. We all understand why our particular development as a community has not, so far, favored the cultivation of this special science; but our very existence and prosperity as a Society is a striking evidence of how readily interest is awakened and of how steadily it is maintained.

The members of the Society already exert a very wide personal influence to increase the general interest in astronomy; and this will grow from year to year. If our members will arrange among themselves to prepare short abstracts of our publications in popular form for printing in the daily newspapers in their vicinity, this influence and our usefulness will be very rapidly extended.

Let me leave the subject of the development of the Society, and address myself to the special topic I have proposed to treat. I wish to give you what may be called the unofficial or personal view of life and work at the Lick Observatory.

We all know the official and impersonal side, and it is, of course, by far the most important one; in a sense, it is the only one. There is the great Observatory, founded by private generosity, and carefully equipped with instruments of the best design. There is the corps of observers, who have already done much with the opportunity afforded them. This is the official view of the institution, and the publications of the astronomers in the various scientific journals are the official vouchers for their work. This is a more or less familiar view of the Observatory, and, as I say, it is the official one. It is like the view which is obtained during a summer visit to Mt. Hamilton, when the landscape is smiling in the sun, and when everything wears its holiday dress. Nothing is more charming than the drive to and fro; nothing seems simpler than the organization of effort and work; nothing seems (and nothing is) so delightful as a life of devotion to one's chosen profession among such beautiful and grand surroundings, as one of a company of fellow-workers.

There is, however, another side to the life at Mt. Hamilton, which I may call its personal aspect. It is not in opposition to the

Lick Observatory in Winter.
(By the courtesy of *Himmel und Erde*.)

first view, but rather its complement. No one of the astronomers is less attached to his science and to his work for any incidental hardships there may be in this life; in fact, you cannot know how sincerely and devotedly he is attached until you yourself know both sides of his existence. I have thought that I might give you some idea of this other half of our lives without running the risk of dealing with too familiar and intimate matters. If I can do so, you will conceive of the whole institution as it really is, and not as it seems to be; and you will have some idea of the total activity, and not simply of the astronomical effort. Before the least scientific work can be done, life must somehow be organized. If the shutters of the great dome are frozen tight together, the great telescope cannot be used. If there is no wood to burn in the office-stoves, no computations can be made, no matter how enthusiastic may be the computer. If the chimneys of the Observatory will not draw, it is beyond any man's power to work at his desk, be he never so devoted. These matters must be attended to somehow. The energy that is left over is available for the astronomical work.

The life of an isolated and highly specialized community ought to have something interesting quite in itself; and I wish, if I can, to give you some idea of our life as a whole. If I succeed in this, I shall have written a chapter in the history of the Lick Observatory which is certainly worth writing, although it has no place among official records, and although it assumes a friendly and interested audience—which, I am sure, I may count on. Allow me, then, to begin by showing you some exquisite winter views of the Observatory from photographs by Mr. BURNHAM and Mr. BARNARD.

The wood cuts which accompany this paper have been kindly presented by the editors of *Himmel und Erde*, the *Universal Review*, *Engineering*, and by Messrs. WARNER & SWASEY, to whom our thanks are due. They will serve to recall the various aspects of the landscape to those who have once seen it. I regret that it is impossible to show some of the most characteristically beautiful winter effects, even by the photograph. One has to live at Mt. Hamilton to see them. They cannot be photographed. Sometimes for days and days we are under a huge hemispherical cup of cloud whose rim is lifted up a few degrees all around the horizon. Outside of this envelope the sun is shining brightly on the snowy tops of Monte Diablo, Loma Prieta, Santa Lucia and on the range of the Sierras from the Yo Semite far southwards along the great valley, and all of

these glorious mountain outlines are in full view. No one who has seen this sight can ever forget it; but there is no way to reproduce it for others.

The photolithograph (from a negative by Mr. BURNHAM) gives a general view of the summit of the mountain on February 21st, 1890, at the end of the severest snow-storm of the season. The drifts near the small dome are ten feet deep, and those near the astronomers' cottages at the foot of the hill are even deeper, so that the quarters present something the appearance of an Eskimo *igloo.*

In order to give some definite notion of a severe winter's weather, let me copy part of the record for November and December, 1889, and January and February, 1890:

METEOROLOGICAL OBSERVATIONS FOR THE MONTHS OF NOVEMBER AND DECEMBER, 1889, AND JANUARY AND FEBRUARY, 1890.

(From November 1st to 15th the weather was mostly clear or fair. The present record commences with the 16th. The mean annual barometer is 25.766 inches.)

DATE.	Mean Daily Barometer.	Rain or Melted Snow.	For 24 hrs. ending at noon. Maximum Velocity of the Wind.	For 24 hrs. ending at noon. Total Movement of the Wind.	REMARKS.
	Inches.	*Inches.*	*Miles.*	*Miles.*	
Nov. 16, 1889	25.81	. . .	60	159	Clear.
" 17 "	25.77	. . .	50	142	Fog.
" 18 "	25.61	.73	37	542	Rain.
" 19 "	25.80	.91	28	362	Rain.
" 20 "	25.82	1.66	17	259	Rain.
" 21 "	25.87	.15	24	312	Clear.
" 22 "	25.69	.14	30	638	Fog.
" 23 "	25.77	.60	28	282	Cloudy.
" 24 "	25.85	. . .	10	119	Clear.
" 25 "	25.95	. . .	30	285	Clear.
" 26 "	25.81	. . .	33	564	Fair.
" 27 "	25.63	. . .	60	880	Cloudy.
" 28 "	25.58	. . .	60	821	Cloudy.
" 29 "	25.60	.06	50	841	Cloudy.
" 30 "	25.60	.21	33	510	Cloudy.
Sums. . . .	. . .	4.46	. . .	. . .	

GENERAL VIEW OF THE SUMMIT OF MOUNT HAMILTON, February 20, 1890.

Date.			Mean Daily Barometer.	Rain or Melted Snow.	For 24 hrs. ending at noon. Maximum Velocity of the Wind.	Total Movement of the Wind.	Remarks.
			Inches.	*Inches.*	*Miles.*	*Miles.*	
Dec.	1,	1889	25.57	.70	26	772	Rain.
"	2	"	25.71	.34	33	767	Fog.
"	3	"	25.70	.29	30	326	Fog.
"	4	"	25.57	.63	43	756	Rain.
"	5	"	25.52	.53	60	775	Rain.
"	6	"	25.49	1.01	37	561	Rain.
"	7	"	25.71	1.50	50	736	Rain and fog.
"	8	"	25.62	.94	18	290	Rain.
"	9	"	25.82	.21	37	503	Fog.
"	10	"	25.60	.59	50	530	Rain.
"	11	"	25.51	.52	43	705	Rain and fog.
"	12	"	25.56	.04	17	231	Fog.
"	13	"	25.71	.17	14	226	Fog.
"	14	"	25.74	. . .	17	164	Fog.
"	15	"	25.78	. . .	10	167	Clear.
"	16	"	25.77	. . .	43	372	Cloudy.
"	17	"	25.72	.58	24	245	Rain and partly clear.
"	18	"	25.69	.08	43	513	Snow.
"	19	"	25.83	.71	30	459	Rain.
"	20	"	25.79	1.53	60	400	Rain and fog.
"	21	"	25.54	.05	60	. . .	Fog.
"	22	"	25.45	.19	. . .	. . .	Snow.
"	23	"	25.31	.04	. . .	. . .	Snow.
"	24	"	25.41	.58	. . .	. . .	Rain and fog.
"	25	"	25.65	.78	. . .	. . .	Rain and cloudy.
"	26	"	25.71	.06	22	501	Fog.
"	27	"	25.75	.03	20	254	Fair.
"	28	"	25.82	.08	26	287	Fog.
"	29	"	25.95	.35	24	291	Rain and cloudy.
"	30	"	25.74	.10	28	386	Fog.
"	31	"	25.68	.56	33	459	Rain and fog.
Sums. . . .			. . .	13.19	. . . .	. . . .	

Date.		Mean Daily Barometer.	Rain or Melted Snow.	For 24 hrs. ending at noon. Maximum Velocity of the Wind.	Total Movement of the Wind.	Remarks.
		Inches.	*Inches.*	*Miles.*	*Miles.*	
Jan.	1, 1890	25.64	. . .	15	269	Fog.
"	2 "	25.50	.60	50	. . .	Rain.
"	3 "	25.35	. . .	. . .	. . .	Snow.
"	4 "	25.39	. . .	. . .	. . .	Snow.
"	5 "	25.57	.11	. . .	. . .	Fog.
"	6 "	25.68	.30	. . .	. . .	Fair.
"	7 "	25.85	.22	. . .	. . .	Clear.
"	8 "	25.82	.14	22	412	Clear.
"	9 "	25.76	. . .	28	253	Cloudy.
"	10 "	25.65	.18	17	202	Clear.
"	11 "	25.82	. . .	22	342	Clear.
"	12 "	25.86	1.29	33	445	Rain.
"	13 "	25.85	.06	. . .	199	Fair.
"	14 "	25.83	. . .	50	436	Clear.
"	15 "	25.66	. . .	60	482	Snow.
"	16 "	25.58	.41	27	509	Snow.
"	17 "	25.54	.69	30	. . .	Snow.
"	18 "	25.67	.07	. . .	. . .	Fog.
"	19 "	25.84	.05	. . .	. . .	Fog.
"	20 "	25.81	.01	. . .	. . .	Fair.
"	21 "	25.64	.01	. . .	. . .	Fair.
"	22 "	25.67	. . .	. . .	. . .	Fog.
"	23 "	25.65	. . .	60	. . .	Rain.
"	24 "	25.59	2.09	62	237	Rain.
"	25 "	25.57	1.10	24	253	Rain.
"	26 "	25.76	.11	. . .	541	Clear.
"	27 "	25.82	. . .	. . .	. . .	Clear.
"	28 "	25.89	. . .	. . .	612	Fair.
"	29 "	25.83	.37	. . .	345	Rain.
"	30 "	25.86	.12	12	145	Cloudy.
"	31 "	25.88	. . .	15	183	Clear.
Sums. . . .		. . .	7.93	. . .	. . .	

View of Astronomer's Cottage, Lick Observatory, February 20, 1890.

Date.	Mean Daily Barometer.	Unmelted Snow.	For 24 hrs. ending at noon. Maximum Velocity of the Wind.	For 24 hrs. ending at noon. Total Movement of the Wind.	Remarks.
	Inches.	*Inches.*	*Miles.*	*Miles.*	
Feb. 1, 1890	25.93	. . .	12	203	Fair.
" 2 "	25.93	. . .	14	257	Fair.
" 3 "	25.93	. . .	13	110	Fair.
" 4 "	25.97	. . .	24	378	Clear.
" 5 "	25.94	. . .	22	349	Fair.
" 6 "	25.90	. . .	19	311	Clear.
" 7 "	25.89	. . .	13	147	Fair.
" 8 "	25.83	. . .	13	100	Clear.
" 9 "	25.83	. . .	33	526	Clear.
" 10 "	25.96	. . .	24	345	Clear.
" 11 "	26.05	. . .	10	112	Clear.
" 12 "	25.87	. . .	43	395	Clear.
" 13 "	25.67	. . .	24	298	Clear.
" 14 "	25.74	. . .	37	541	Fair.
" 15 "	25.59	. . .	70	. . .	Fog.
" 16 "	25.37	1	22	. . .	Fog.
" 17 "	25.41	7	* . . .	. . .	Snow.
" 18 "	25.39	12	. . .	. . .	Snow.
" 19 "	25.49	13	. . .	. . .	Snow.
" 20 "	25.49	14	. . .	. . .	Snow.
" 21 "	25.50	9	. . .	. . .	Snow.
" 22 "	25.72	8	. . .	. . .	Fair.
" 23 "	25.67	. . .	. . .	. . .	Fair.
" 24 "	25.62	. . .	. . .	. . .	Fog.
" 25 "	25.53	2	. . .	. . .	Fog and snow.
" 26 "	25.61	. . .	. . .	. . .	Clear.
" 27 "	25.81	. . .	. . .	. . .	Clear.
" 28 "	25.76	. . .	. . .	. . .	Fair.
Sums. . . .	. . .	66	. . .	. . .	

* After this date the anemometer was frozen so that no record was obtained.

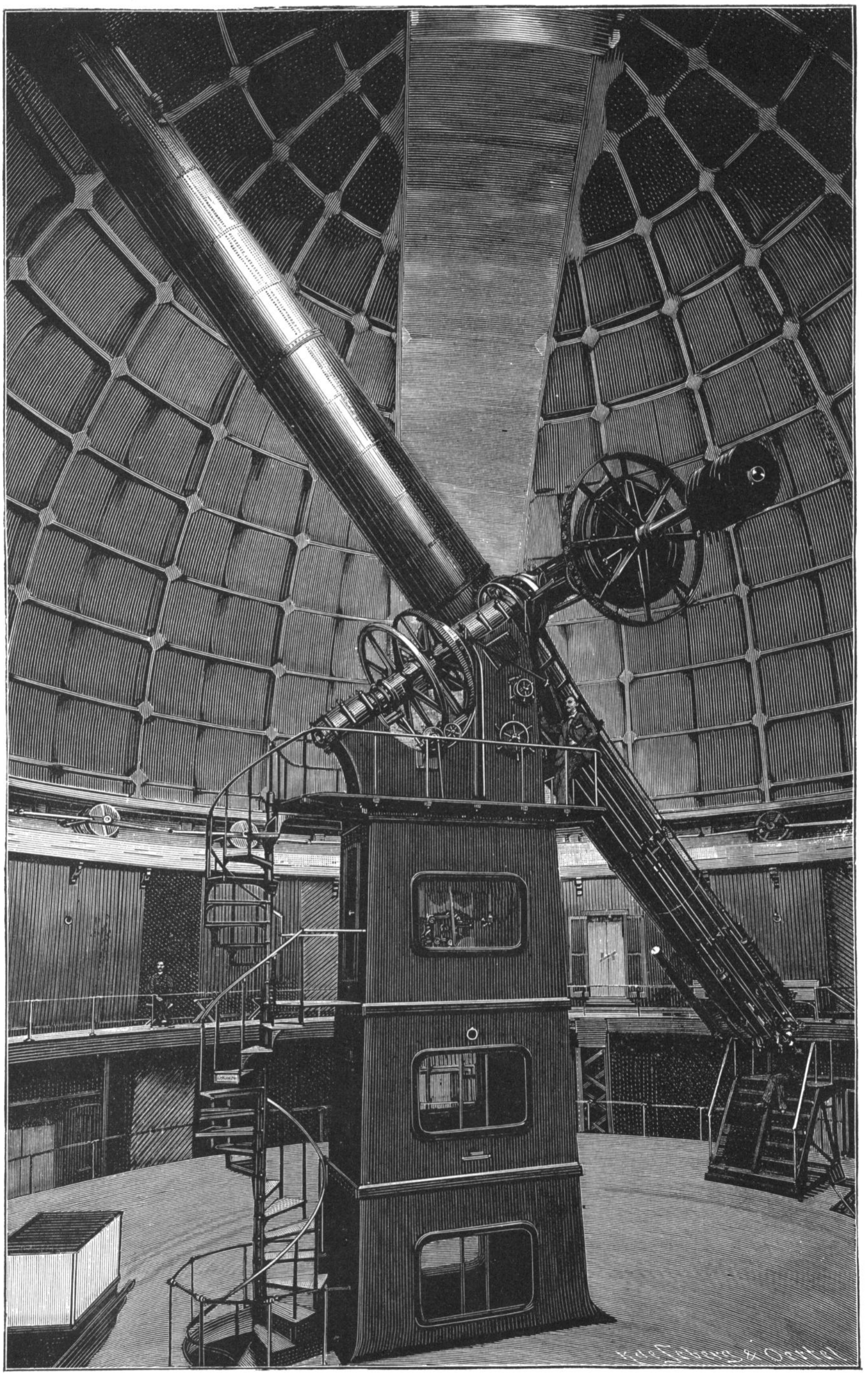
The total *snow*-fall was for December, 29 inches; for January, 51 inches, and for February, 66 inches, or *twelve feet* in all. Some of the January snow was on the ground when the February storms began. During five days of February, 1890 (the 16th to 20th), absolutely no communication with the outside world was *possible.* The snow fell in immense quantities, and a fierce *blizzard* was blowing which could not be faced. On the sixth day of our imprisonment three men started together for Smith Creek, and returned the same night, bringing a mail and thirty pounds of much needed provisions, after a journey of fourteen miles, which had taken something like eight or nine hours of very hard work.

To take the Observatory as a whole, we must consider not only the astronomical establishment, with its purely scientific aims, but, rather, the reservation of 1900 acres, with its village, containing a colony of thirty to forty people and eight or nine families. There are ten different sets of quarters occupied at the present time by astronomers, students and workmen.

There is no want which can be felt in the city which is not equally pressing here. But consider how difficult it sometimes is to supply these wants. Take even the case of mere food-supply during our winter storms. There is nothing to be had nearer than San José, twenty-six miles away, and it is necessary to transport everything by the stage.

Frequently the stage has not room for all our parcels, and very frequently has no passengers for the Observatory, and stops at the foot of the mountain. In such a case, we must send our own men and wagon over the fourteen miles of road to the valley of Smith Creek. Very often during the past winter the road has been impassable to wagons (on account of the snow), and all our supplies have been brought in the mail-bag on horseback. Whatever was too large or too heavy for the bag was not brought, and had to be done without. During the one hundred and twelve days from November 15th to March 8th, the stage only came to the Observatory thirty-six times. The difficulties in this matter can be met by a kind of "forehandedness"; but when we come to the strictly scientific side of our necessities, they are more serious. For example, a bit of colored glass is wanted, to moderate the brightness of *Mars*, so that the satellites can be more easily seen. Where is it to be had? There is not so much as a square millimeter of such glass west of the Allegheny mountains.

One of the prisms of our spectroscope is stained and yellow, so that part of the blue end of the spectrum is cut off. It cannot be



Thirty-six-inch Telescope, Lick Observatory.
(By the courtesy of *Himmel und Erde*.)

repolished nearer than Pittsburg. If it is sent away, we lose its use for a month or more. San Francisco has everything that is needed for its business life; but, every now and then, our very special needs absolutely cannot be met nearer than New York or Europe. This means delays, and possibly a loss of the work in hand. The want of a particular kind of chimney for our standard photometric lamp (which had to be imported from Europe, finally, after fruitless attempts to buy it or to have it made in America) delayed the appearance of our Eclipse Report from May to October, for example. Another parcel ordered from London in March, was not delivered here till the following December, and so on. The negatives of the Solar Eclipse of December 21st remained at the foot of the mountain from February 16th until March 5th, for lack of some way to bring them up. The Eclipse instruments were delayed in San José for nearly two months before they were finally delivered.

All this experience has developed the resources and ingenuity of our astronomical staff to a very high degree. To take a single example, I may mention the very ingenious and satisfactory electric control to the driving-clock of our great equatorial, which was invented by Mr. KEELER, and made in the Observatory out of the simplest materials.* It has completely taken the place of the elaborate device which preceded it. But, I think, any mechanic would be disposed to smile at the composite nature of the construction. As in this case, so in very many others. If anything has to be done, the first question is, How? And the next, Where? The usual answer is, if we do not do it ourselves it will be finished too late for our use. And the usual result is that the apparatus is made here, as best we may. All great observatories except our own have an instrument-maker attached to the staff, who can even construct a new instrument, if necessary—and we anxiously look forward to the time when such an official can be added to our own force—when it will not be necessary to use ability of high class in doing merely mechanical work. At the end of every two hours of every night the observer must leave his work and wind the huge weight of the driving-clock of the great telescope (600 lbs.; 320 half turns of the handle!) which has run down. From this really severe labor he must return, with steady nerves (if possible) to making delicate micrometer measures—to moving a spider line over little distances like the $\frac{3}{10000}$ths of an inch ($= 0''.1$), till it just bisects the

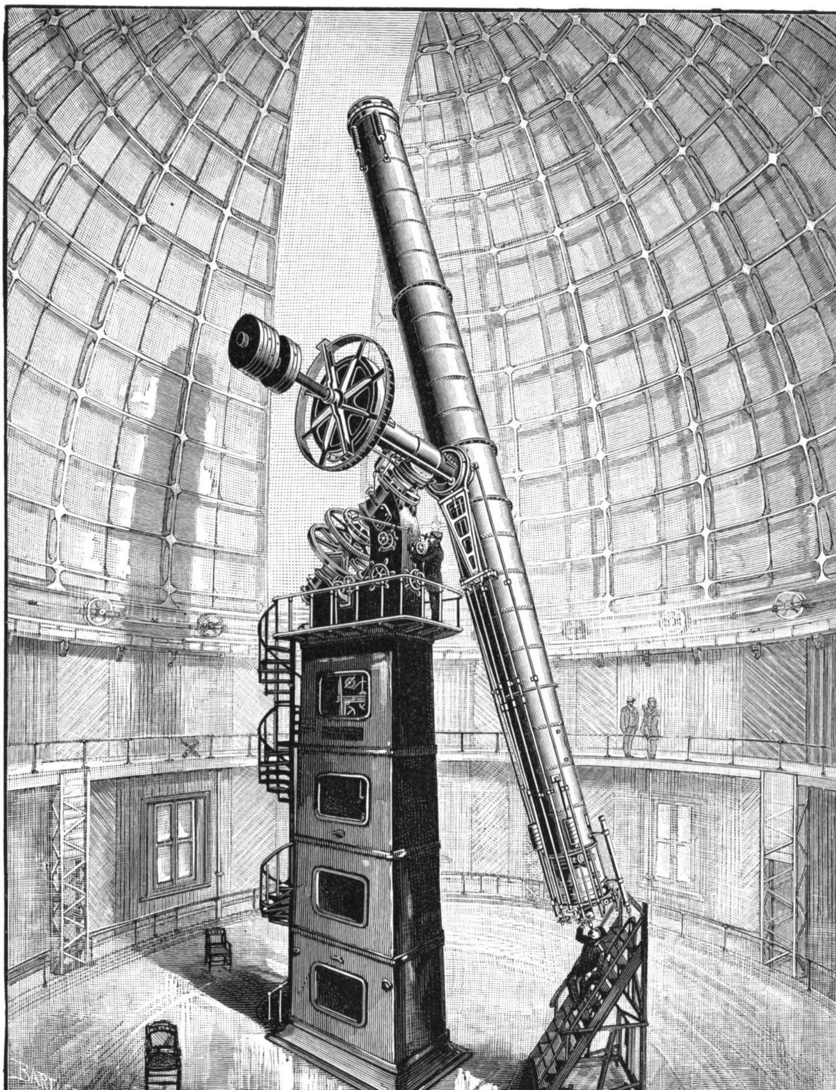
* See *Publications* Astronomical Society of the Pacific, No. 6.

disc of a planet, a comet, or a star. A very few dollars would supply us with a water-wheel to wind our weight, but the money is not yet available. You have all seen the exquisite negatives and prints made by our two distinguished photographers, Messrs. BURNHAM and BARNARD; but perhaps you have not considered that every particle of this work has been done by these gentlemen in addition to their regular astronomical observations.

If we had (as I hope that we soon may have) a regular photographic assistant, his whole time could be well spent in carrying out the work connected with this subject—in making prints and enlargements, etc., from the negatives taken by the astronomers at night.

The frontispiece to the Lick Observatory Eclipse Report of last January is an interesting example of what must needs be done. The funds allotted to the Observatory did not allow us to illustrate our report. The printing of the text was excellently executed at the State Printing Office in Sacramento. The edition was one thousand copies, and every one of those copies has a beautiful silver print of the corona for a frontispiece. How did it come to be there? Over one thousand five hundred prints were made by Mr. BARNARD, and the one thousand best ones were selected. Each of these thousand prints was separately mounted by him on cardboard, and sent to the printer; and in that way our report was suitably illustrated. The cost was only a few dollars. If it had been more, we should have been obliged to forego the opportunity. The other cuts in the report we owe to the kindness of the Council of the Royal Astronomical Society, who presented us with electrotypes from their own publications.

There are countless instances of the kind which could be cited. The great telescope was designed to have its circles read by means of electric lights; but the Observatory was turned over to the Regents before these were provided. It was legally "completed" at that transfer. Consequently, we cannot read the circles at all at night, and shall not be able to until we are able to save enough money out of our scanty annual appropriation to buy the necessary appliances. Part must be saved this year, and part the next, and so on, till finally *this* want is supplied. The Observatory is only one department of the University, and there are very many pressing calls for money at Berkeley which the Regents must consider. In my opinion, they have allotted for our annual expenses all that can be spared from the University income without injuring the development of the whole institution; but, while we do not ask for more, the sum is inadequate. It is but six-tenths of one per cent. of the first cost



THIRTY-SIX-INCH TELESCOPE, LICK OBSERVATORY.

(By the courtesy of Messrs. WARNER & SWASEY.)

of the Observatory. I often think that the foresight, intelligence and industry which is required to use this sum so that our astronomical work may not absolutely come to a standstill, would, if applied in business, produce ten times our present annual income. It is not easy, at first sight, to understand the necessity for constant small changes in apparatus and instruments which, when effected, make the difference between absolutely first-class and merely good results. The idea of those who do not reflect is, here is a telescope; look through it and "discover" something! The real question is to arrange every detail of the apparatus and work, so that one can improve a little on the splendid results obtained by the other great telescopes of the world, directed, as they are, by the most skillful and accomplished observers. It is by attention to relatively small improvements in apparatus, etc., that relatively great advances are made. The difference between the REPSOLD and the DOLLAND heliometers gave to BESSEL the parallax of 61 *Cygni.*

While such changes and expenses must be provided for, there are vast fields of work always open to any astronomer with any powerful instrument; and at the Observatory we are able to point to our past history, and to prove by it that we have not neglected our opportunities. The object of the present paper is to show how these opportunties have to be made first and improved afterwards, under special circumstances of situation and endowment. It would be a most ungracious task to point out the hindrances, if we could not refer to satisfactory achievement obtained in spite of them.

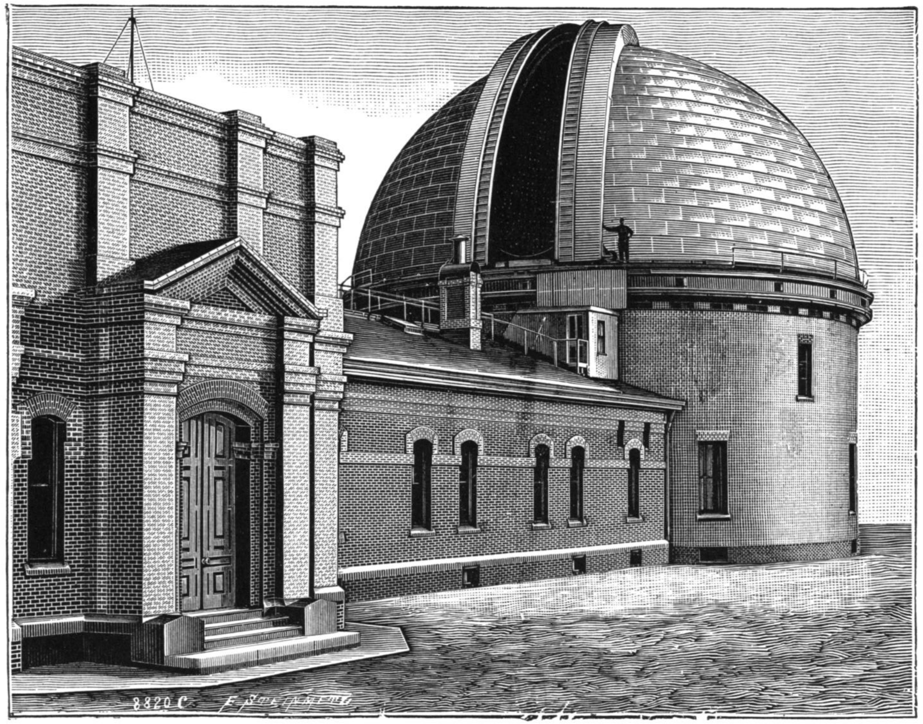
I think there is hardly any department in which we feel so cramped for funds as in that of the library. It is more than a year since we have been able to purchase a single new book. Such an establishment as our own should have a library of 15,000 to 20,000 volumes to begin with, on the branches of mathematics, physics, geodesy and astronomy, and it would require an annual outlay of about one thousand dollars to provide for the merely necessary accessions. It is not as if we were situated near some of the great libraries of the East, so that the works of occasional use only could be omitted from our special collection. On the contrary, it is necessary to possess these. To discover what is new, we must be able to verify what is already known. I am not willing to leave this subject without a grateful acknowledgment of the many valuable gifts to the Observatory library from academies of science, observatories and individual astronomers, both at home and abroad. Through their kindness, the Observatory receives nearly all the current publications by gift and

in exchange, and in very many cases we have been presented not only with current volumes, but with long series of past publications.

It would have been entirely impossible to have put the Observatory into its present efficient condition had it not been for the earnest and whole-hearted coöperation of the Regents of the University and of their Secretary, who have waived all minor technicalities in the way of doing our official business, and have simply inquired whether such and such an action or expense was necessary. The waiver of unnecessary routine has saved at least a year of work to the Observatory, and it ought to be and is gratefully acknowledged by all of us.

Every necessary of life at Mt. Hamilton must be provided by individuals, except water. That is furnished by the Observatory. To distribute this, we have a system of four reservoirs, with several miles of pipes, under and over ground and in the buildings. All the motive power used in revolving the great dome, or in raising its floor, depends on the water-supply, and the slightest accident to the windmill, or to a reservoir, or to the pipes (by freezing or otherwise), stops the work of the great telescope. After every snow-storm a whole day's work, and sometimes more, is necessary to get the revolving parts of the dome into satisfactory working order. The springs supply no more than 300 to 400 gallons of water daily in the dry season, but fifty times as much in the winter; the daily expense varies from 1000 to 1200 (say forty gallons per man per day, including the photographic laboratories, the stables, etc.). This is a relatively small daily individual expense, as will be seen by comparison with other places.* The reservoir capacity is not sufficient to store water enough to carry us through the dry season (June–October). Hence, every year it has been necessary to use for domestic purposes some of the rain-water collected during the winter and stored for use as power. All this water has passed many times through the water-engines and hydraulic rams, and is therefore covered with a heavy film of oil, and is really unfit for use, and produces more or less illness when it is used. But it *must* be used. There is no other. There is absolutely no present remedy. It will be necessary to provide a greater storage or a greater supply. Either of these things can readily be done; but either will require an expense which there is no present way of meeting. In the meantime there is nothing to be done but to make the best of the conditions and to be as prudent as may be in using the available supply. Every day's supply weighs

* Daily expense per individual, in New York, 72 gallons; Chicago, 118 gallons; Boston, 79 gallons; Milwaukee, 155 gallons; San Francisco, 50 gallons.



South Half of Lick Observatory.
(By the courtesy of *Engineering*.)

8000 lbs., and it must be lifted vertically 412 feet, in order to make it available. In one hour's work with the steam-pump we can raise a little over two days' supply. But the smallest leak in pipes or valves anywhere in the system is fatal. Therefore, in the dry season the most careful watch is kept on the various reservoirs, and they are read daily.

I think that the numerous very light earthquakes have much to do with producing the cracks which we find in the walls and the bottoms of our reservoirs. Even the slightest crack must be quickly discovered and stopped, at the risk of imperiling our daily provision.

The supply of fuel must be found somewhere in the neighborhood, and delivered before the roads become too heavy for hauling. It is the present policy not to cut any wood on the reservation, and hence it must be found where best it may, and its delivery hastened as much as possible. During the winter of 1888-9 the only wood available for the Observatory and for the various households was from my private store, which had been ordered in May, but which was not all delivered till the following February! The procrastination of our immediate neighbors has ceased to be annoying. It is majestic—colossal—like a great feature of nature. It must be reckoned with like the inexorable forces of heat, magnetism, gravitation.

During the severe winter of 1886-7, the Lick Trustees were obliged to collect wood along the stage-road, and it was delivered in small parcels, like express packages. Even so, it was impossible to keep the houses warm, and the water froze on the very dining tables! The photographic lens of the great telescope was worked by Mr. CLARK in water so cold that it froze where it was not immediately under his hands, and this because no room in the Observatory could then be warmed above the freezing-point.

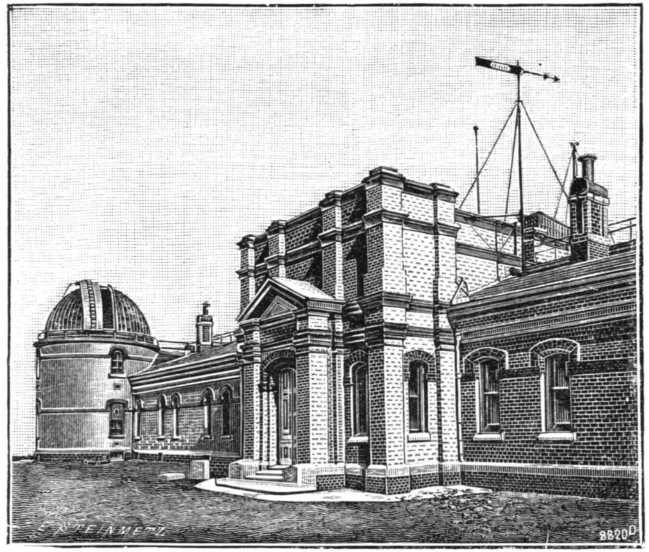
After the fuel has been obtained, it is often a serious problem to keep any fires. Out of six offices there are only two in which a fire can be lighted in all winds. In one of the brick dwellings fires will not burn in a southeast wind, and in the other a north wind is equally fatal. The wind sweeps up the deep cañons on either side, and blows almost vertically down the flues, so that the flames are driven out into the room several *feet!* or else volumes of smoke make it simply impossible to remain in the apartment. Our meals have been served in the halls, in the bedrooms, or not at all! It goes without saying that all sorts of experiments have been tried to cure this defect; a treatise on ventilating chimney-tops could be written from actual examples of discarded patterns now on hand. There is no remedy for this trouble except a rebuilding of the defective chim-

neys themselves on a new plan, and this is now impracticable.

A telegraph line of two wires, seventeen miles in length, connects the Observatory with San José. The distance by the road is twenty-six miles. The Observatory is responsible for maintaining this line, so that its daily time-signals may not fail; and besides this, it is absolutely necessary to maintain the telephone-wire; for all the supplies for the Observatory and for our astronomical colony have to be ordered in San José. Woe to the luckless housekeeper who forgets to order a dinner in time to have it brought up by the stage of that day! Remember it, or do without it, is the stern rule of practice. If, by chance, the stage does not come, or if the driver has forgotten the order, one has only the melancholy satisfaction of having done all that could be done, and one dines a little better for this.

During the summer season everything works easily. There are no heavy winds and no snow-storms, and the telegraph line needs very little attention. Occasionally we hear of a wire broken or a pole down, and must send a laborer to mend it. But in the winter all is different. The snow gathers on the wires and freezes into solid ropes, four or five inches in diameter. The fierce winds blow this mass about, and either break the heavy wires, or tear them off the poles, or even overthrow the poles themselves. There is nothing for it but to equip a wagon with everything that is necessary—ladders, wires, tools, insulators—and to send off two men, for two or more days, to find and repair the damages, which may be miles away from us. During February the telephone line was completely buried under snow and broken in a dozen places for about two weeks, and it was impossible to repair it.* It has been extremely fortunate that no case of serious illness has occurred during any one of our snow blockades. Under the most favorable circumstances we are sufficiently far from medical assistance; and there have been times when no surgeon could have arrived here for several days after the time when he might have been needed. The wind mill at our lowest reservoir (Huyghens) is the source of all our power. It is carefully furled during storms; but once each winter, at least, it is blown far off to leeward, smashing the sixteen-foot wheel. Before the break comes heavy iron pieces, nearly two inches in diameter, must be fractured. This occurs during the gusts of storms where the average wind velocity is sixty-five or seventy miles. I have no doubt that the velocity of these gusts is eighty or more miles. We have had, as yet, no opportunity

* It is now destroyed and useless.



North Half of Lick Observatory.
(By the courtesy of *Engineering*.)

to *measure* such velocities, for our anemometer has always disappeared at the same time,—blown off to leeward. The Chief Signal Officer has been kind enough to lend us an anemometer of a new pattern, copied from the one which was successful on Mount Washington. So far we have not been able to measure the high velocities even with this instrument, for it has frozen fast to its support during the blinding storms of hail, snow and wind.

The problem of providing suitable instruction for the children of the astronomers is a serious one. It has hitherto been solved in various ways—none satisfactory—either by private tuition in the family, or by sending the children away to boarding-schools, or, finally, by maintaining one house on the mountain and one in San José near the schools. This is a very practical question in every respect. Its final solution will, probably, be the establishment of a public school on the reservation itself.

It has been rather an amusing and novel experience to undertake some culture experiments on the mountain. The usual vegetation is a scanty grass, a little wild oats, the scrub oak *(chapparal)*, the Douglas oak, the Digger pine, a few specimens of the golden oak (a beautiful evergreen tree), with stunted manzanitas, Gowrias, and in one place a little patch of wild grapevines. There is no doubt that the nobler varieties of oaks and pines can be made to grow here, together with the chestnut, the cherry, the apple, the plum and other fruit trees. We have found that the Monterey pines and cypresses do capitally; and we take great pride in a little avenue of such young trees, which are now more than a year old. In my own garden I have twelve varieties of roses, which, so far, flourish. Some of the astronomers and students have been really successful in this work, and have quite transformed the appearance of their immediate surroundings. Mr. BARNARD's garden, for example, contains geraniums, violets, mignonette, etc., which do well, with care. Such hardy flowers as marigolds will care for themselves, and we are all proud of the scanty growth of wild oats which has been coaxed into existence on the bare rock of the summit-level.

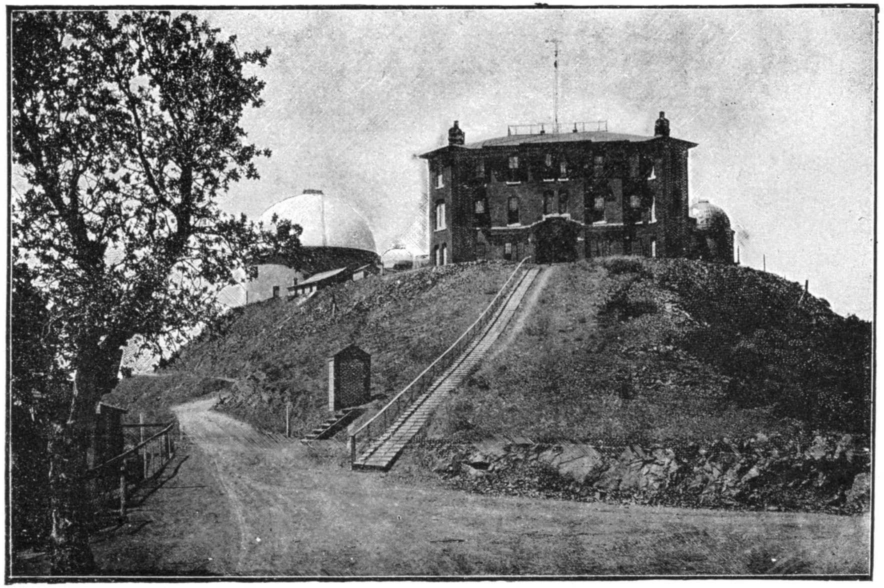
It is a very practical matter to encourage such growths, for they serve to keep down the dust and to make all our observations in the day-time more accurate by covering up the bare rocks and shielding them from the intense heat of the sun.

The process of planting a young tree is interesting. In the first place, the loose soil, an inch or so thick, is removed, and then the surface of the rock appears. If we go down three or four feet, this

rock is as blue and solid as trap-rock, which it very much resembles when first uncovered. It is, however, nothing but a blue sandstone *(arcose)*, and whenever it is exposed to the air, it rapidly disintegrates. Frequent slight earthquakes and the effects of frost fill the upper and more exposed layers with little cracks. To plant the tree the tolerably solid portion must be attacked, and great masses, two feet or more in diameter, must be removed in single pieces. Finally, we succeed in getting a good-sized cavity, which is then filled with rich soil. The little tree must be protected from the high winds on the windward (southeast) side, and, finally, it must be watered during the dry season. But the sturdy young pines we have already reared amply reward us for all trouble, and they have already changed the aspect of the place. It is a thousand pities that this culture has been neglected until now. There is no reason why the whole vicinity of the summit should not now be covered with pines and chestnuts, and with the nobler varieties of oaks. We must wait another ten years for this to be accomplished. During the last season large quantities of wild-oat seed and of buckwheat have been spread on the barren slopes of the hills, and in a few years these will be covered with a mat of vegetation. A tract of eight or nine acres has been plowed, and is now sowed in oats, barley and rye, and we expect to raise all our own forage in future.

The desolate slopes of the summit, which consist of mere loose rocks, must be covered with some kind of vegetation to consolidate them. Already the outer edges have sunk two feet or more in various places, and we shall soon be reduced to the small platform of solid rock, unless these slopes can be protected by vines and roots. This work, too, has been commenced, and in a few years we hope, at least, to see our slopes saved, and also to see them covered with vines and creepers. At the immediate summit the present rock walls must be soon replaced with brick. Every winter destroys many feet of the present walls, and soon there will be little or none left.

I remember well that when I reported for duty at the Naval Observatory in Washington (where the dome for the great telescope was then building) the first question asked me was not an astronomical, but a practical one, "Do you know how cement ought to be mixed?" In my experience since then I have found that every sort of practical knowledge came into full play in the course of scientific work. At no place could there be a greater demand for it than at the summit of Mount Hamilton. The ingenuity of the extraordinary beings of JULES VERNE'S stories would be severely



Lick Observatory from the Cottages.
(By the courtesy of *The Universal Review*.)

taxed to meet the numberless small exigencies of a year. One should be farmer, gardener, engineer, millwright, carpenter, builder, machinist, all in one. I have sought, with a certain measure of success, to obtain something like a numerical estimate of the quantity and variety of things which have been done during the past nineteen months. It is the system at the Observatory to keep a memorandum of the "extra work to be done" on cards, one or more items on a card. At the proper time the card is handed to the person who is to do the work, and, when it is finished, the card is returned. Of course, many of these memoranda are now lost, as they have no permanent value; again, a great many things have been done from verbal instructions alone. Some items call for half an hour's work, while many require a week's labor. Moreover, none of the regular routine work is represented by such memoranda, but only the *extra* work, which, once done, will not have to be done again. I have had the curiosity to have these cards counted, and I find that there still remain 1168 of them, which may correspond to 2000 of the original ones, or to, say, 3000 to 4000 separate items, or to 8000 or more hours of *extra* labor. The Secretary's letter-press copying-books for the same period contain 5100 pages of letters, mostly mere orders for materials for building or repairs. These letters correspond to about 500 working days. More than 650 checques have been issued in payment of bills. Perhaps such very rough statistics will appear trivial to others. To me they seem to stand for milestones, and to have a real value, as showing how far we have come, and, especially, as indicating a road over which, happily, we shall never be forced to travel again.

In what has gone before I have sought to give something like an adequate view of the unofficial, personal and incidental side of life at the summit of our mountain, and to show how closely this personal side is bound up with the official; how the latter, in fact, depends for its value on the good organization of the former. This chapter seems to me to be worth writing, and I hope it will have been of interest to the members of this body who visit Mount Hamilton every year at the regular summer meetings of our Society, and who are therefore familiar with one aspect of the Observatory. I hope, also, that I have avoided presenting too familiar and intimate details; and I hope, still more, that I have not seemed to exaggerate the difficulties of the case into an importance which they do not deserve. They actually exist; they will all be gradually overcome. For the present,

they are part and parcel of our circumstances. To estimate the work of the Observatory rightly, they must be taken into account. I may safely leave it for others to say that they have by no means dismayed our company of astronomers, but that they rather have incited them to new efforts. I shall be glad to have indicated, even thus summarily, a few of the directions in which the Observatory needs and deserves to be helped. If our wants are once known, I feel sure that they will be remedied.

A MECHANICAL THEORY OF THE SOLAR CORONA.

By J. M. Schaeberle.

[Abstract.]

Mr. Schaeberle presented a paper entitled "A Mechanical Theory of the Solar Corona." He stated that his investigations seemed to prove conclusively that the solar corona is caused by light emitted and reflected from streams of matter ejected from the sun, by forces which, in general, act along lines normal to the surface of the sun; these forces are most active near the centre of each sun-spot zone.

Owing to the rotation of the sun, the streams of matter will not lie along normals, since the angular velocity of different portions of the stream grows less as the distance from the sun increases; in other words, the streams are of double curvature. Each individual particle of the stream, however, describes a portion of a conic section, which is a very elongated ellipse so long as the initial velocity is less than 383 miles per second (assuming that the sun's atmosphere, as shown by various observations, is exceedingly rare).

The variations in the type of the corona admit of an exceedingly simple explanation, being due to nothing more than the change in the position of the observer with reference to the plane of the sun's equator. *According as the observer is above, below, or in the plane of the sun's equator, the perspective overlapping and interlacing of the two sets of streamers cause the observed apparent variations in the type of the corona.*

Mr. Schaeberle then exhibited a model, in which the sun is represented by a ball about an inch in diameter, from which radiate a number of needles, to represent the streams of matter. All these needles are contained between two zones corresponding to $\pm$ 30° of